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ORIGINAL ARTICLE

Can we gain an advantage by combining distal median, radial and ulnar nerve blocks with supraclavicular block? A randomized controlled study

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Abstract
Purpose The aim of this study was to compare the combined ultrasound-guided supraclavicular brachial plexus block (SCB) and distal median, radial, and ulnar nerve blocks, with the supraclavicular block alone.
Method Sixty-two patients undergoing upper extremity surgery were randomized to supraclavicular only (Group S, $n = 31$) or supraclavicular + distal (Group SD, $n = 31$) group. Patients in Group S received 32 mL of 1.5 % lidocaine + epinephrine 5 μg/mL, while those in Group SD received 20 mL of 1.5 % lidocaine + epinephrine 5 μg/mL followed by distal median, radial, and ulnar nerve blocks using equal volumes of 2 % lidocaine + 0.5 % levobupivacaine (4 mL/nerve). Sensory and motor blocks of the ulnar, median, radial and musculocutaneous nerves were assessed every 5 min starting at the 10th minute. The imaging, needling and performance times were recorded. Also, the onset and anesthesia-related times, need for analgesic and first analgesic times, were noted.
Results In Group SD, the anesthesia onset [15 (10–25) vs. 20 (15–30) min, $p < 0.001$] and anesthesia related times [16.6 (10.7–28.2) vs. 22 (15.9–33.7) min, $p < 0.001$] were significantly shorter than those of Group S. Additionally, the analgesic requirement was lower in Group SD (56.7 vs. 88.5 %, $p = 0.009$), while among the patients who required analgesic, the first analgesic time was longer in Group SD in comparison to Group S [625 (347–1764) vs. 315 (233–746) min $p < 0.001$].
Conclusions The addition of distal median, radial, and ulnar nerve blocks to SCB shortens anesthesia-related time and anesthesia onset time when compared with a SCB alone.

Keywords Ultrasound · Peripheral nerves · Anesthetics · Local

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Introduction

Peripheral nerve blocks have several advantages compared to general anesthesia. Improved analgesia, decreased nausea and vomiting, and early discharge are some of the benefits of these blocks [1]. However, knowing the value of time, space and manpower, the overall anesthesia-related time of nerve blocks remains an important challenge in daily clinical practice. Different techniques aiming to reduce anesthesia onset time, which is the major component of anesthesia-related time in peripheral nerve blocks, have been investigated with diverse results [2–4]. Concomitant administration of local anesthetics (LA) at separate sites along the brachial plexus is a new approach to shorten the onset time [4].

With the introduction of ultrasonography in the field of peripheral nerve blocks, a supraclavicular approach to brachial plexus has gained popularity with higher success rates and fewer complications [5]. Furthermore, supplementary distal median, radial, and ulnar nerve blocks

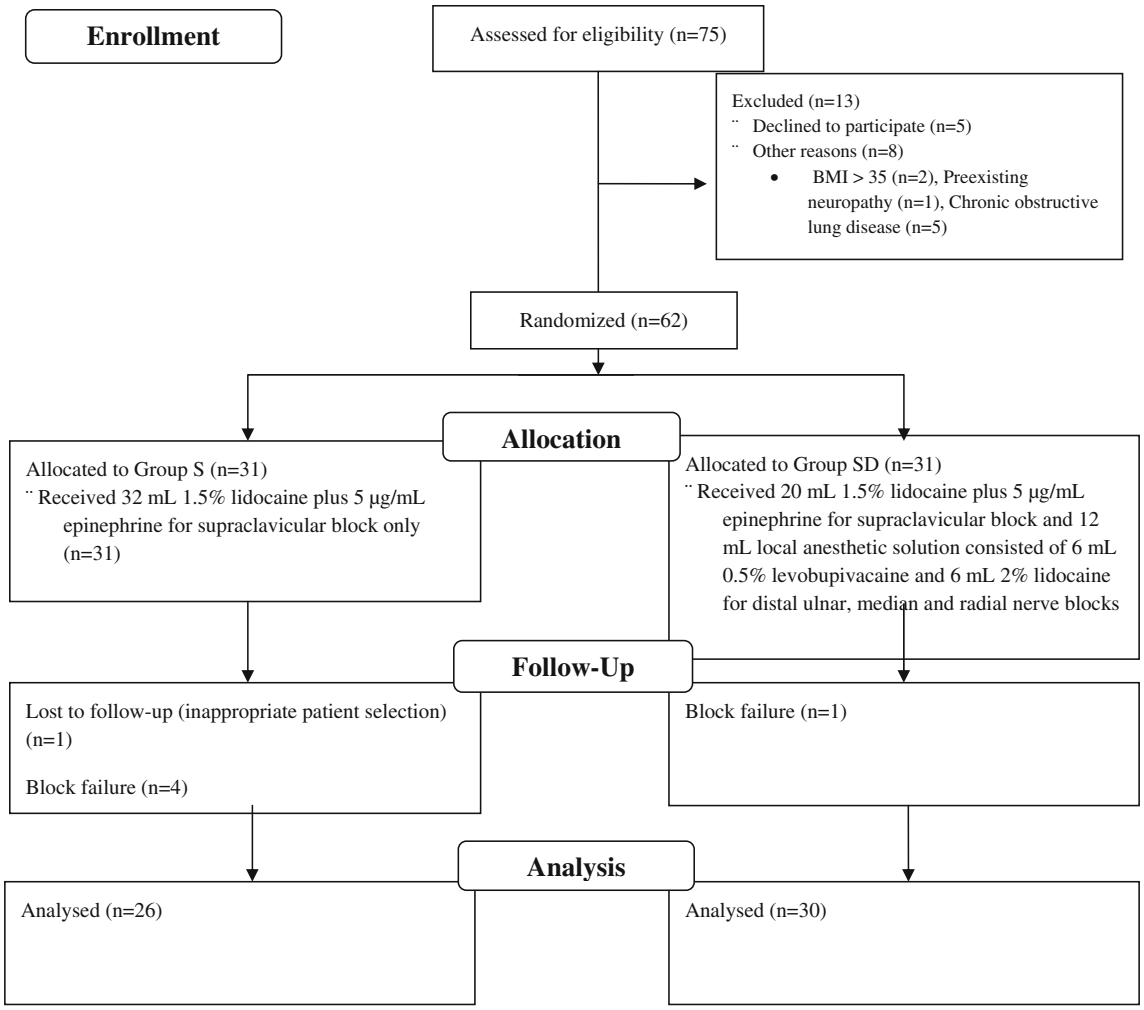

Fig. 1 Overview of the study group

performed at the forearm and elbow levels are used as rescue blocks for failed brachial plexus blocks [6]. However, to our knowledge, the effect of the concomitant use of distal blocks on the onset time of supraclavicular brachial plexus block (SCB) has not been investigated up to now.

The primary aim of this study was to evaluate whether the addition of distal median, radial, and ulnar nerve blocks would shorten the onset time of SCB compared to a SCB alone. The secondary aim of this study was to compare the anesthesia success rates.

Materials and methods

After obtaining Institutional Review Board approval (Ankara University Faculty of Medicine Ethical Committee, February 2012) and written informed consent, 75 patients undergoing surgery of forearm, wrist and hand were screened for the study. The study was recorded to www.clinicaltrials.gov with the registration number NCT01989312. Patients were aged between 18 and 80 years and all had American Society of Anesthesiologists (ASA) physical status I–III. Thirteen of those 75 patients had our exclusion criteria, which are patient refusal, preexisting neuropathy, coagulopathy, allergy to agents used, pregnancy, body mass index >35 kg/m^2, chronic obstructive pulmonary disease, infection or previous surgery in the supraclavicular area, and systemic infection. Therefore, from 75 patients, 62 were enrolled and included in the study (Fig. 1).

Patients were randomized to either SCB (Group S, $n = 31$) or SCB and additional ultrasound-guided ulnar, median and radial nerve blocks (Group SD, $n = 31$) group using computer-generated Random Allocation Software (http://random-allocation-software.software.informer.com).

After arrival to the operating room, an 18- or 20-gauge intravenous (iv) catheter was placed in the contralateral arm according to the surgical site. All patients were premedicated with 0.03 mg/kg of midazolam intravenously following routine ASA monitoring. All blocks were

performed by two anesthesia fellows (M.O. and B.C.M). All patients first received a SCB with an 18-G Tuohy needle Portex Epidural Minipack (Smiths Medical, Kent, UK) using a high-resolution 8- to 12-MHz linear ultrasound probe (Vivid-I; GE, Wauwatosa, WI, USA). Patients were placed supine with the head slightly turned to the non-operated side and the ultrasound probe was placed in a coronal oblique plane above the clavicle to obtain a short-axis view of the subclavian artery. The time between probe installation to the supraclavicular fossa and the identification of the brachial plexus was recorded as imaging time. Once the subclavian artery and the brachial plexus divisions were identified, a skin wheal was raised with 3 mL of 1 % lidocaine. Then, the 18-G Tuohy needle was advanced from lateral to medial direction using an in-plane technique, and once the needle tip reached the inferior aspect of the plexus, the LA solution was incrementally injected. Thirty-two mL of 1.5 % lidocaine with epinephrine 5 μg/mL was given in Group S (a total of 35 mL of LA solution) and 20 mL of 1.5 % lidocaine with epinephrine 5 μg/mL was given in Group SD (a total of 22 mL). The time interval between the needle insertion and the end of LA injection was recorded as needling time. Thus, performance time was defined as the sum of imaging and needling times.

Needle passes were also recorded. First pass was defined as the initial needle insertion and an additional pass was counted if the needle required further advancement after at least 10 mm retraction and redirection [7].

After the SCB, patients in Group SD received additional ultrasound-guided ulnar, median and radial nerve blocks. The performance times of these blocks were not added to the overall procedural time as they were done after the SCB. In consequence, all these three blocks were performed before the first block testing, during the first 10 min after SCB, adding no extra time to the procedure. All these blocks were performed with the same linear probe (Vivid-E; GE) and a 22-G, 50-mm-long, insulated needle (Stimuplex D; B.Braun, Melsungen, Germany) using an in-plane technique. Twelve mL of LA solution of an equal volume of 2 % lidocaine and 0.5 % levobupivacaine (4 mL/nerve) was used. The aim of these procedures was to surround each nerve with LA solution.

Distal nerve blocks were performed with the arm of the patient abducted to 90° and externally rotated with the palm facing up. The ultrasound probe was placed approximately at the mid-forearm. The aim of this position was to visualize both median and ulnar nerves at the same level and to perform both blocks via a single needle entrance. Firstly, the ulnar nerve was located at the medial side of the ulnar artery and was surrounded with 4 mL of LA mixture. Then, the needle was withdrawn to the subcutaneous tissue and, once the median nerve was located between the flexor digitorum profundus and flexor digitorum superficialis muscles, the needle was redirected toward the median nerve and this nerve was surrounded with 4 mL of LA mixture. And, finally, for the radial nerve block, the arm was adducted and internally rotated with the forearm resting on the patient's chest [4]. Then, the radial nerve was located approximately at the junction of the middle and distal thirds of the arm, just distal to the nerve leaving the humeral spiral groove. Once the nerve was located, it was surrounded with 4 mL of LA mixture [4]. During the performance of distal blocks, to minimize pre-scanning time, one anesthesia fellow (M.O.) was preparing (positioning and sterilization) the patient while another (B.C.M) was performing the blocks. In both groups, the operative arm was wrapped with a bandage to cover the needle entrance points and thereby to blind the researcher before testing the block onset more distally [4].

An investigator blinded to the group allocation evaluated the sensorial pinprick and motor blocks of the ulnar, median, radial and musculocutaneous nerves at 10, 15, 20, 25 and 30 min after the completion of SCB. Sensory blockades of each nerve were evaluated on the palmary face of the fifth finger for the ulnar nerve, on the palmary face of the third finger for the median nerve, on the dorsal face between the thumb and second finger for the radial nerve and on the lateral aspect of the forearm for the musculocutaneus nerve. The sensory blocks were quantified on a 3-point scale relative to the contralateral arm as 0 = no sensory block, 1 = sensation of touch, no pain, 2 = no sensation. Motor blockades were evaluated by finger abduction for the ulnar nerve, second and third finger flexions for the median nerve, wrist extension for the radial nerve and elbow flexion for the musculocutaneous nerve. The motor blocks were also quantified on a 3-point scale as 0 = no motor block, 1 = reduced power, 2 = no movement. Readiness for surgery was defined as a minimal total aggregate score of 14 points with the sensory block score equal or superior to 7 or 8 points. According to this, the onset time was defined as the time required obtaining 14 points, starting from the withdrawal of the Tuohy needle. Moreover, the anesthesia-related time was defined as the sum of the performance and onset times. If after 30 min a total aggregate score of 14 points was not achieved, the block was assumed as failed and general anesthesia was performed [3].

After the block completion, the patient's procedural pain was evaluated by a numerical rating score between 0 (no pain) and 10 (worst imaginable pain). Also, paresthesia was questioned. The incidence of vascular puncture, Horner syndrome and dyspnea, as well as LA toxicity symptoms, were recorded. Additionally, surgery and tourniquet times were recorded. The need for additional LA infiltration, sedation or general anesthesia was noted.

On the first postoperative day, patients were asked to fill in the first analgesic requirements and first movement of the forearm on a given document. The duration of post-block analgesia was defined as the interval between block completion and the first analgesic requirement. Also, the motor block regression of the forearm was defined as the interval between block completion and the first movement of the forearm. All patients were contacted by phone on the 7th day after surgery and questioned about complications like numbness, motor weakness and pain.

The sample size required for the study was calculated based on the anesthesia onset time benefit between the groups. A study involving SCB using similar volumes as in this current study revealed that the onset time was approximately 18 min [8]. Power analysis identified 50 patients (25 patients per group) as the total sample size required to detect a 7-min difference in anesthesia onset time between groups with a power of 0.93 at the 0.05 significance level. We included 31 patients in each group allowing for possible dropouts.

The SPSS 11.5 (SPSS, Chicago, IL, USA) program was used to perform statistical analyses. Frequency (percent) for categorical variables, median (minimum–maximum) for metric variables were used as descriptive statistics. In order to compare two independent groups in terms of metric variables, the Mann–Whitney U test, in terms of categorical variables Chi square test was performed. Statistical significance was considered as $p < 0.05$.

Results

A total of 62 patients were recruited. One patient in Group S was excluded from the study because the surgical procedure was a fracture repair which is more painful then all other procedures included. Also, 4 patients in group S and 1 patient in Group SD were classified as block failure due to a total aggregate score of lower than 14 points after 30 min. Four of them needed general anesthesia while one patient in Group S needed adjunct LA infiltration. Therefore, 26 patients in Group S and 30 patients in Group SD were evaluated (Fig. 1). Demographic data and parameters related to surgical procedures are presented in Table 1.

There were no differences between imaging times and number of needle passes between groups. However, the needling time and therefore the performance time were shorter in Group SD (Table 2).

Nevertheless, univariate analysis of variance, in which performance time was taken as covariate, revealed that the performance time did not have any influence on the onset time ($p = 0.651$) or on the anesthesia-related time ($p = 0.084$). The onset time and anesthesia-related time were significantly shorter in Group SD (Table 2). Also, all distal blocks were performed before the first block testing, during the first 10 min after SCB [overall distal blocks time: 195 (72–436) s].

The anesthesia success rate was 87.1 % in Group S and 96.8 % in Group SD. There were no differences between groups related to procedural pain and paresthesia incidences (Table 2). Also, no patient had a vascular puncture, symptoms of LA toxicity or dyspnea. Although statistically not significant, the incidence of Horner syndrome was higher in Group S (Table 2). The number of patients requiring additional sedation during the block performance and surgical procedure was similar between groups (for block performance, 19.2 % in Group S and 36.7 % in

Table 1 Demographic and surgical data

	Group S ($n = 26$)	Group SD ($n = 30$)	p
Sex (male/female)	8/18	10/20	0.838
Age (year)	46 (21–67)	56 (26–80)	0.029
Weight (kg)	77 (48–103)	78 (55–104)	0.717
Height (cm)	164 (150–183)	163 (149–185)	0.987
Surgery (%)			
Hand	14 (53.8)	14 (46.7)	0.754
Wrist	10 (38.5)	12 (40)	
Forearm	2 (7.7)	4 (13.3)	
Surgery time (min)	27 (8–180)	21 (9–83)	0.742
Touniquet time (min)	32 (0–103)	30 (7–100)	0.495

Values are median (minimum–maximum) or number (percent)

Table 2 Block details

	Group S ($n = 26$)	Group SD ($n = 30$)	p
Imaging time (second)	24.5 (5–150)	19 (3–70)	0.175
Needling time (second)	88.5 (26–240)	74 (30–180)	0.023
Performance time (second)	116.5 (34–330)	90 (40–190)	0.017
Number of needle pass (n)	2 (1–5)	2 (1–4)	0.416
Onset time (min)	20 (15–30)	15 (10–25)	<0.001
Anesthesia related time (min)	22 (15.9–33.7)	16.6 (10.7–28.2)	<0.001
Failure rate (%)	12.9	3.2	0.354
Success rate (%)	87.1	96.8	0.354
Procedural pain(NRS)	2.5 (0–7)	3 (0–8)	0.277
Paresthesia (%)	16 (61.5)	17 (56.7)	0.712
Horner's syndrome (%)	9 (34.6)	7 (23.3)	0.351

Values are median (minimum–maximum) or percentage (%)

NRS numerical rating score

Table 3 First movement of the forearm and first analgesic times

	Group S	Group SD	*p*
First movement of the forearm (min)	238 (163–293)	232.5 (116–460)	0.657
Need for analgesic (%)	88.5	56.7	0.009
First analgesic time (min)	315 (233–746)	625 (347–1764)	<0.001

Cells represent median (minimum–maximum) except for the need for analgesic for which frequency (percent) was given

Group SD, $p = 0.23$, and for surgical procedure, 15.4 % in Group S and 6.7 % in Group SD, $p = 0.40$).

Time to first movement of the forearm was similar among groups. Analgesic requirement was significantly higher in Group S compared to Group SD (88.5 vs. 56.7 %, respectively, $p = 0.009$), and, among the patients who required analgesic, the first analgesic time was shorter in Group S (Table 3).

Patient follow-up at the 1st week after the surgery revealed that one case in Group S and one case in Group SD had numbness in the hand for 14 days. Additionally, another case in Group S complained about a burning sensation in the shoulder, which resolved at postoperative 5th day. There were no significant differences between groups related to these parameters.

Discussion

The results of this randomized prospective study revealed that the addition of distal ulnar, median and radial nerve blocks to SCB shortens the anesthesia onset and anesthesia-related times. Also, postoperative analgesic requirement was lower with the combination without changing the first mobilization time significantly.

The onset time and anesthesia-related time for the SCB group are in concordance with other studies related to SCB [3, 6, 8]. However, in our study, the combination of distal blocks with SCB resulted in an onset time benefit of 5.6 min (20.9–15.3) and an anesthesia-related time benefit of 6.3 min (23.2–16.9). Although this benefit seems like a minimal clinically important difference, this corresponds to an approximately 30 % time benefit on anesthesia-related time, when compared to SCB only.

Tran et al. have shortened the onset time by using the double injection technique in SCB [3]. However, this gain was offset by a longer needling time and therefore they could not reduce the anesthesia-related time. In another study, Roy et al. tried to shorten the time for complete sensory block with double injection technique compared to single injection [9]. But their results were in accordance with the previous study. In our study, combining the distal blocks with the single injection technique has shortened the anesthesia-related time significantly. Therefore, this combination technique could be a reasonable alternative to the double injection technique for accelerating the anesthesia-related time of the SCB.

Also, in recent studies, it has been shown that the success rate for SCB is 87 % [3, 11]. Our results are in accordance with the literature with a success rate of 87 %. Although the combination of distal blocks with the supraclavicular approach has increased this success rate to 97 %, this result did not reach a statistically significant difference in the sample size because the primary endpoint of this study was anesthesia-related time, which determined the sample size.

In several studies, it is stated that ulnar nerve territory is frequently incompletely blocked with a supraclavicular approach [6, 10]. For that reason, the infraclavicular approach is frequently defined as the first choice for hand surgery [6]. On the other hand, our results reveal that the sequential additions of distal blocks to the SCB not only shorten the onset time but also increase the consistency of the block. Fredrickson et al. have combined an infraclavicular brachial plexus block with distal blocks and showed that anesthesia onset time was accelerated and the block consistency was improved [4]. Our study is in agreement with the results of Freidrickson et al. concerning the method of combining more proximal blocks with distal adjuncts.

Several techniques are described for the postoperative pain management. Placement of a catheter is frequently used for this purpose [2, 3]. Another method used for postoperative analgesia is using long-acting LA for brachial plexus blocks. Nevertheless, this method does not correlate well with the modern needs of care. As the outpatient surgical procedures are increasing, the need for early mobilization and the control of the forearm increases. Therefore, sufficient pain management with early recovery of motor functions is required in this setting. For that, a lower concentration of long-acting LA such as ropivacaine or levobupivacaine can be suitable as they produce differential sensory and motor blocks. Also, the addition of long-acting LA as distal blocks during the procedure can be a good alternative. The aim of this method was to achieve a rapid onset and short duration anesthesia and to control the tourniquet pain by short-acting LA used for SCB, while producing a good postoperative analgesia without motor block with long-acting LA added as distal blocks. In our study, this method achieved a postoperative pain management for approximately 11 h until the first analgesic need. Furthermore, again in Group SD, a considerably high portion of the patients did not require any additional pain therapy later on. This may be mostly explained by the use of levobupivacaine for distal blocks, which is a long-acting LA without motor block.

The incidence of Horner syndrome is defined as 20–90 % in the literature [12]. In our study population, this rate was 35 % for Group S and 23 % for Group SD. Although statistically not significant, this decrease in Group SD has been attributed to the lower volume of LA used at the supraclavicular region in Group SD compared to Group S.

The major limitation of this study is the use of different LA in the two groups. Using different LA limits the comparison of the absolute difference between the two techniques. The longer action of levobupivacaine added to the distal block may have influenced the postoperative effects of the combination technique. Although this study aimed to examine adding distal blocks to shorten the anesthesia onset and anesthesia-related times compared to SCB alone, use of different kinds of LA in these two groups is not very suitable for drawing a conclusion on the advantage of addition of distal blocks.

Also, in this study, the pre-scanning time, defined as the time needed for the preparation of all the equipment (LA solutions, ultrasound probe dressing, needles, etc.) required for the blocks, was not recorded. Including pre-scanning time with the anesthesia-related time could have influenced the overall time benefit achieved by adding distal blocks to the supraclavicular approach in a negative manner. On the other hand, performing a nerve block to an already anesthetized nerve can be criticized due to the risk of nerve injury, even when using ultrasound guidance. However, SCB onset times were reported as longer than 10 min in several studies [2, 3, 8]. In our study, all distal blocks were performed in less than 10 min, and therefore the median, ulnar and radial nerves were not expected to be totally blocked at the time of the distal block procedures. Another potential limitation of this study is that the patients were not blinded to the study groups. Also, the statistically significant difference between the patients' ages in two groups may have influenced the results of anesthesia-related times. Nevertheless, the possible effect of patients' ages is a controversial issue in the literature, which may or may not have any effect on anesthesia-related times [13, 14]. However, we think that the difference in our groups is clinically small and correspondingly can be negligible with regard to our results.

In conclusion, the addition of distal ulnar, median and radial nerve blocks to the SCB shortens the anesthesia onset and anesthesia-related times compared to supraclavicular block alone. Furthermore, this technique can be an effective and safe alternative for the postoperative pain management of outpatient forearm and hand surgery with a shorter motor block time when long-acting LA are used for distal blocks.

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